Cryo-Cooler

Installation and operation manual

Bruker Advanced Supercon GmbH

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Before taking the device into operation carefully read this manual

Contents

1. Important Notice

Prior to operate the system and to prevent damage to the system please read the instructions of the manufacturer CRYOTHERM first. This manual contains important information regarding the installation and operation of the Cryo-Cooler.

You must read carefully this manual before installing and testing the device.

In the event of any uncertainties or questions, please contact Bruker ASC. Only persons familiar with the operation of Cryo-Systems and vacuum technology shall carry out installation and handling of the Cryo-Cooler. This manual describes the installation and the operation of the automatic and manual functions of the Cryo-Cooler.

All information provided within this manual have been carefully checked and found correct. Bruker ASC, however, does not assume any liability for any and all failures and/or errors caused by incorrect use which are not covered by the warranty provisions.

Safety warnings are posted throughout the manual, please see chapter 1.1 Explanation of warning notices. These warnings are designated by an appropriate symbol inside an equilateral triangle. The level of danger is described according to an alarm keyword.

1.1. Explanation of warning notices

To avoid injuries during operation of the Cryo-Cooler the manual has warnings notices implemented to protect the operators from injuries. Here a basic overview of the warning levels, and their meanings.

DANGER

DANGER indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury. This signal word is limited to the most extreme situations.

WARNING

WARNING indicates a potentially hazardous situation, which, if not avoided, could result in death or serious injury.

CAUTION

CAUTION indicates a potentially hazardous situation, which, if not avoided, may result in property damage

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1.2. Overview of used warning signs

With the following symbols, which are used throughout this manual, potentially hazardous areas or situations are marked. Follow the given remarks to prevent any harm to live or goods!

GENERAL WARNING

Indicates a potentially hazardous situation, which, if not avoided, could result in death or serious injuries.

ELECTRICITY

Danger due to electricity, may result in hazardous situations which, if not avoided, could result in death or serious injuries. All tasks referring to electricity are to be carried out by skilled and trained people.

LOW TEMPERATURE

Indicates a potentially hazardous situation, which, if not avoided, could result in serious injuries through e.g. cold liquids, gases or surfaces. This could e.g. happen while refilling cryogenic liquids.

HOT SURFACE

Indicates a potentially hazardous situation, which, if not avoided, could result in serious injuries through e.g. hot surfaces. This could e.g. happen during a Bake-Out procedure.

2. Introduction to the Cryo-Cooler

2.1. A basic description of the Cryo-Cooler

The Cryo-System is designed to cool the consumer component of a consumer with liquid nitrogen. Liquid nitrogen is supplied to the consumer via transfer pipes by means of a liquid nitrogen pump and takes the heat load off the consumer component. Slightly warmer nitrogen is returned by the second transfer line to the Cryo-System.

Inside the Cryo-System there is a heat exchanger. This heat exchanger is cooled by liquid nitrogen at atmospheric pressure at a temperature of approx. 77 K. This nitrogen is stored inside a vacuum insulated storage dewar. The storage container is part of the Cryo-System and is called Sub-Cooler. The heat exchanger is located in between the pump and the supply line. This circuit is a closed loop system working at overpressure to make sure the liquid nitrogen does not boil and it supplies continuously cold nitrogen to the DCM.

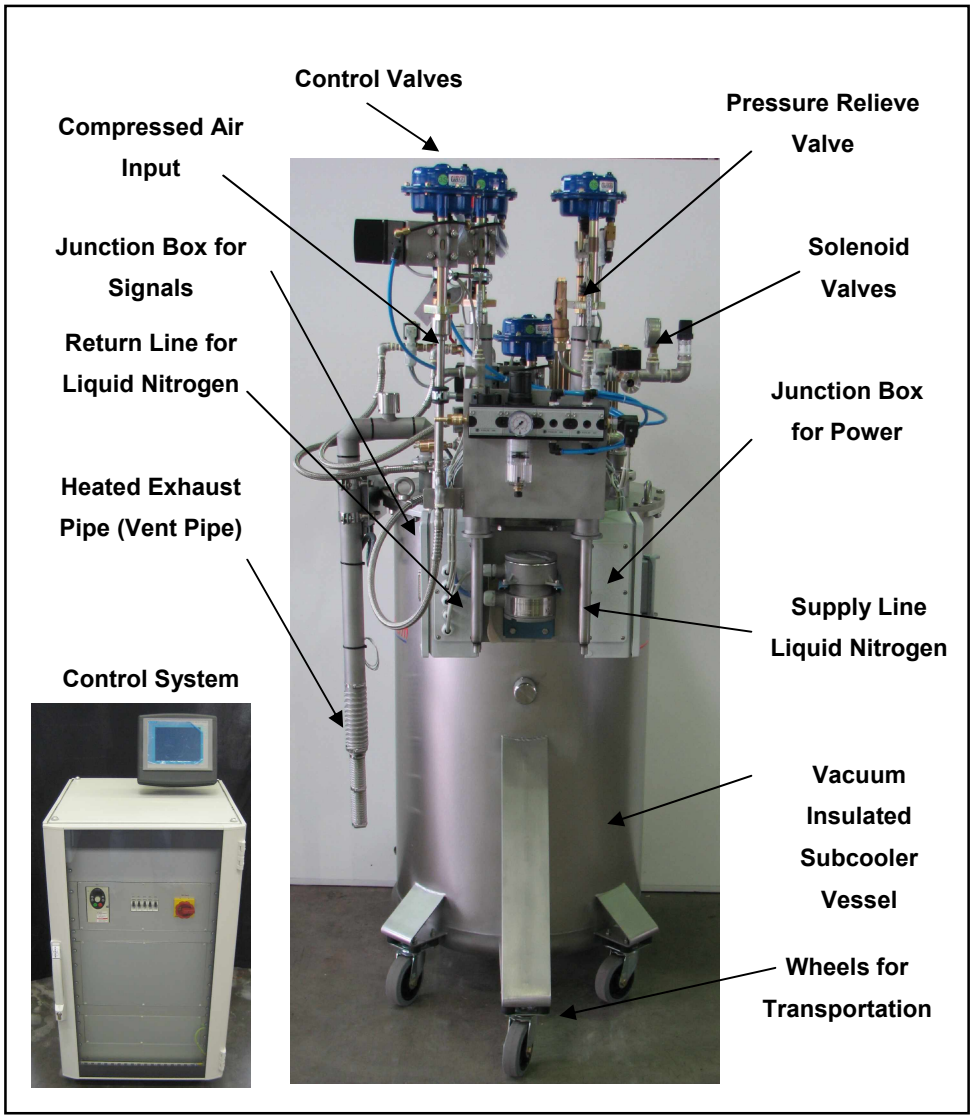
Table 1 Overview of the parts of a Cryo-Cooler

Component	Count	Parts of Component	
Complete Cryo-Cooler	1 x	▪ Sub-Cooler vessel ▪ Liquid nitrogen pump ▪ Valves and gauges ▪ Over pressure relieve valves ▪ Heated Exhaust/vent pipe ▪ Junction box	Including
Liquid nitrogen supply line	1 x		optional
Transfer lines	2 x		optional
Control rack including touch panel	1 x	Optional: 19” rack mounts including touch panel, power distribution crate and PLC crate	including

Interconnecting cables	3 x		including

For the exact position of each part within the Cryo-Cooler please refer to Figure 1.

Figure 1: Main components of the Cryo-System



2.2. Technical Data

Operating Voltage: 230 V + 5 % -10 %

Line frequency: 50/60Hz

Max Operating Current: < 16 Amps

Average Operating Current: ~ 3-4 Amps

Cable length cooler to Control: 20m (opt. length max. 40m)

Compressed air supply: 5-6 bar

Compressed air connection: Tubing inner diameter: 9mm

Compressed nitrogen Supply: 2 bar

Connectivity: KF25 flange

Ambient conditions:

- Temperature during operation 5°C – 30°C
- Relative air humidity 95% non condensing

Liquid nitrogen connection: DN10 connection ¾"–16UNF

Optional: vacuum insulated DN14 Johnston coupling female

Transfer Line connector: CRYOTHERM

Johnston Coupling DN14mm

Max. Nitrogen flow at 80 Hz: > 15 l/min

(depends on the flow restriction caused by the consumer)

Max Heat Load (with consumer): 1500 W

Operating pressure in closed loop: 1 – 5 bar (adjustable)

Optional: 10 bar operating pressure in the closed loop

Liquid nitrogen consumption: < 3 l/h

(without powerload, in short circuit operation, transfer lines <1m)

~ 2.3 l/h

(with consumer, consumption per 100 watt)

Available liquid nitrogen storage volume: 200 l

Pressure stability: < 15 mbar

(@ typical operation parameter)

Interface to Control System (EPS):

D-Sub 9 male

2 outputs: ready and failure/alarm

1 input: Cryo-Cooler enable

Remote access via TCP/IP: Web Access / EPICS / TANGO:

2.3. Dimensions and Weight

Dimensions Cryo-Cooler:	H 200 x L 120 x W 90 cm
Weight Cryo-Cooler:	~ 300 Kg
Dimensions control rack:	H 135 x L 67 x W 61 cm
Weight:	~ 50 kg

2.4. Operating the Cryo-Cooler through the GUI

2.4.1. Short introduction to the GUI

Basically three levels of operation are available:

I. Display Mode
II. System Settings
III. Expert Mode
IV. Operator Mode

Within the display mode you are only able to select the mode (expert or operator mode) or to stop the Cryo-Cooler.

In the System Settings you are able to set the time, change the password, transfer data and shut off the runtime.

The expert is able to operate every valve, to select all frequencies of the pump and to determine the system pressure.

The operator mode offers a limited set of functions to protect the system.

The operator is allowed to select the:

a) Automatic cool-down
b) Automatic warm-up
c) Automatic refill of the heater vessel
d) Stop Function

The operator is not allowed to:

1) Turn on / off the auto refill function of the Sub-Cooler
2) Determine trigger values for auto refill
3) Select the proper drive frequency of the pump

4) To select particular throttle valve settings
5) To select specific operating pressures
6) To turn on / off the pressure control
7) To turn on / off the exhaust heater
8) To select a specific filling level of the heater vessel

2.4.2. Handling of the GUI in the display mode

By default the system starts with de display mode. To enter the expert mode hit the button “Expert Mode”. To enter the operator mode hit the button “Operator Mode”. You will be asked for a password in the following screen. (See Figure 3)

Figure 2: GUI interface layout

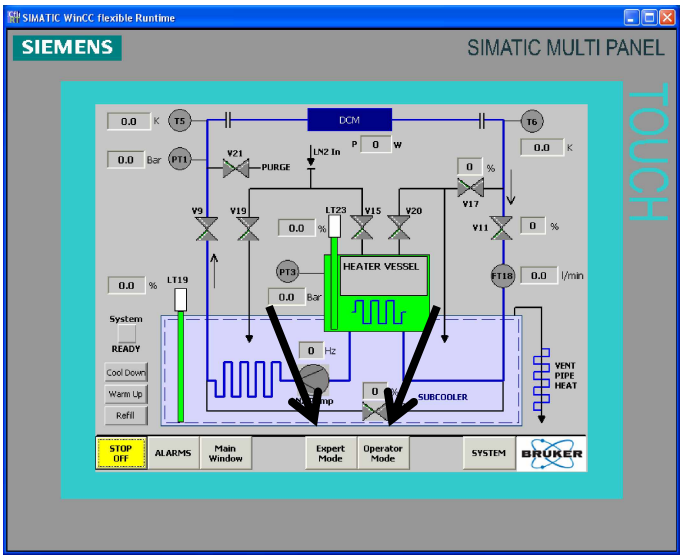
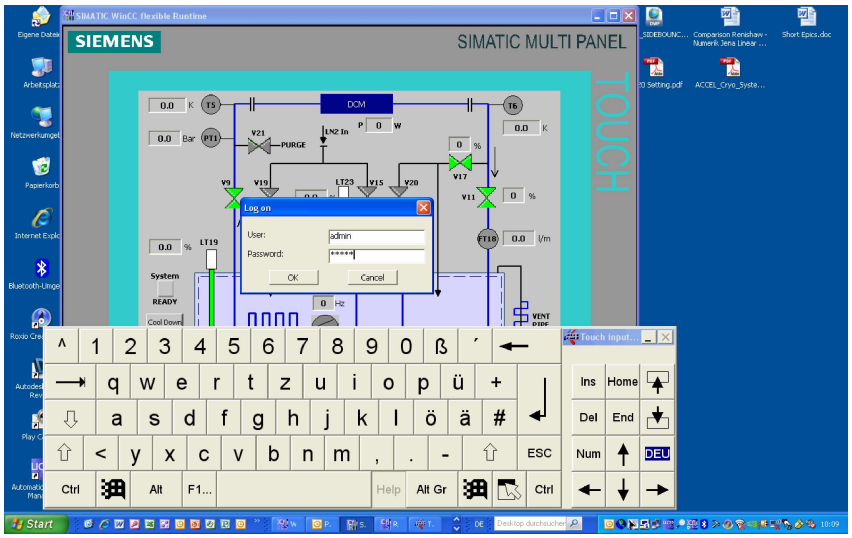


Figure 3: Window for password



The password by default is “admin” for the expert mode and for the operator mode. Now you are allowed to enter the operator mode or the expert mode.

Hit the button “Expert mode” or “Operator mode” again. In case you have selected expert mode, you are now able to operate all components of the cooler manually. In case you have selected operator mode the following window opens up. (See Figure 4)

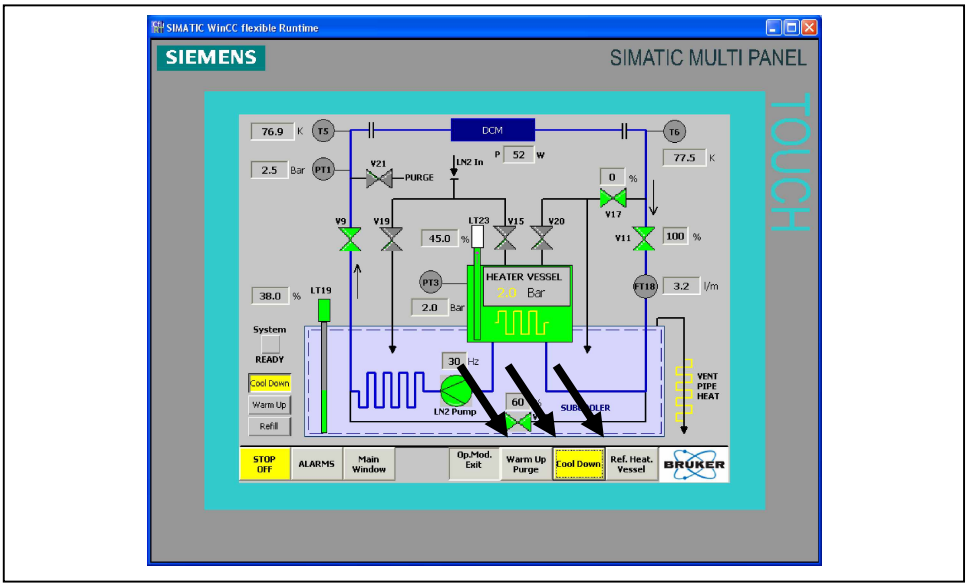
2.4.3. The operator mode functions

Within the operator Mode you will find three new buttons for automatic functions (See black arrows Figure 4):

a. Warm-up
b. Cool-down
c. Refill of the heater Vessel

Prior to select one of these automatic procedures please read the related chapter in chapter ??? of this document.

Figure 4: Operator mode window



To exit the operator mode or the expert mode, hit the “Operator mode exit” button or the “Expert mode exit” button. Enter the password. Select the “Operator mode exit” button or the “Expert mode exit” button, again.
Now the window shown on Figure 2 shows up again and you are able to select either the expert or operator mode.

2.4.4. The expert mode functions

Within the expert mode valves and other components of the Cryo-Cooler can be managed manually with full control.

After logging in to the expert mode the valves and their components change to active fields within the touch screen.

By typing on one of the active areas on the touch screen (See Figure 5: Active areas within the expert mode) an extra windows opens.

In this extra window (See Figure 6: How to Open/Close a valve) the component itself can be controlled manually.

Table 2 Overview of possible status of active areas shows the overview of active components and their status is explained.

Figure 5: Active areas within the expert mode

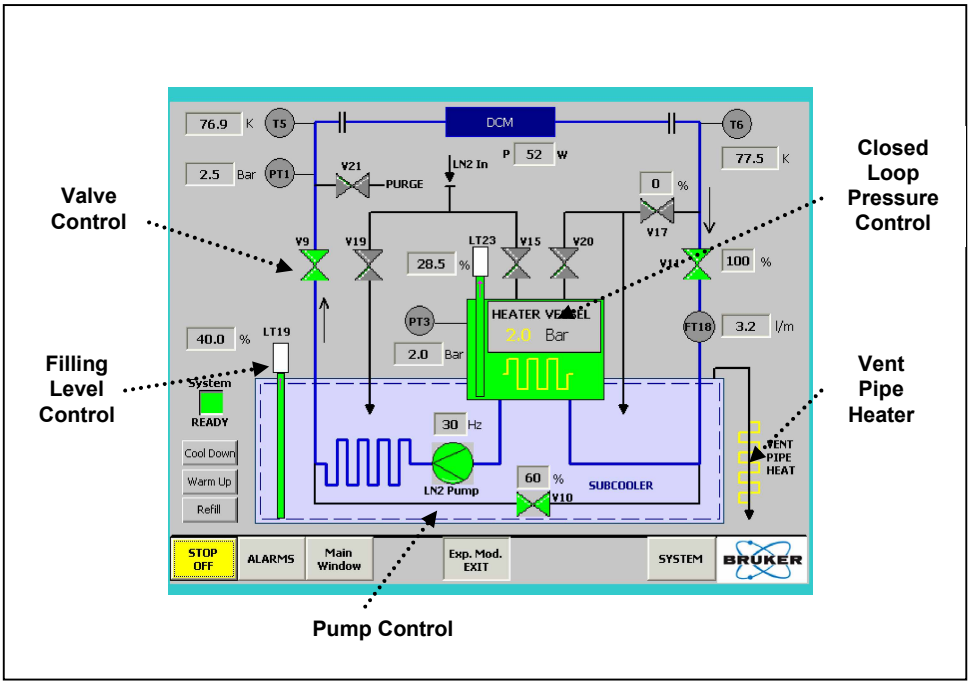
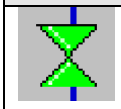
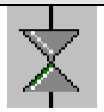
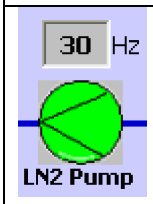
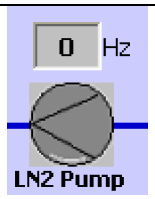


Table 2 Overview of possible status of active areas

Component	Status	Component	Status
	Open Valve		Closed Valve
	Running Pump at 30Hz		Pump Off

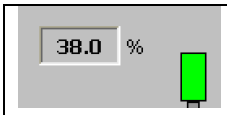
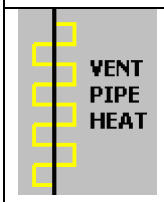
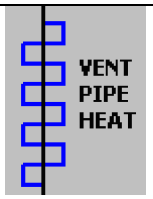
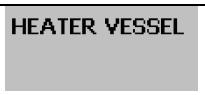
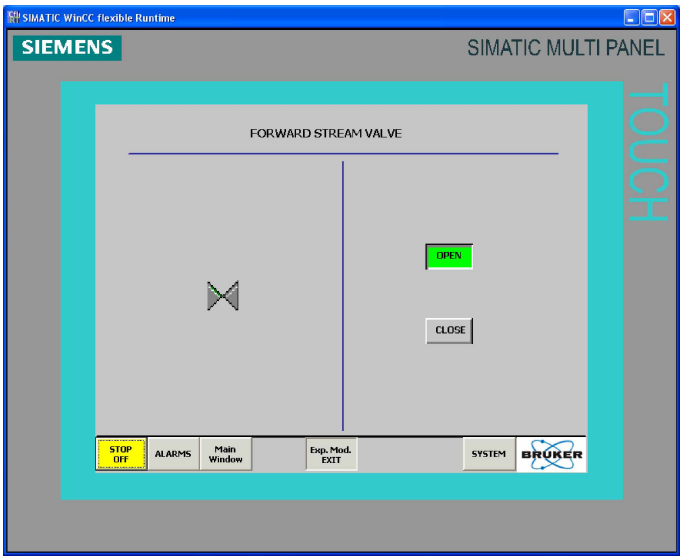
	Filling Level Sensor, auto-refill activated.		Filling Level Sensor, auto-refill de-activated.
	Vent Pipe Heat switched on.		Vent Pipe Heat switched off.
	Pressure Control on, Set point 2bars.		Pressure Control off.

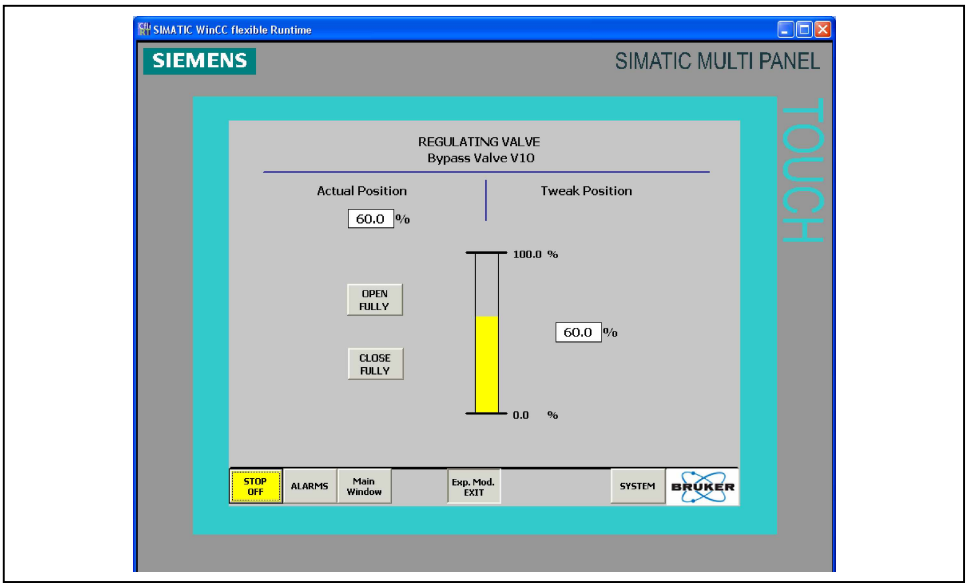
Figure 6: How to Open/Close a valve



By pressing the button “Open” on the touch screen the forward stream valve opens. The button and the symbol of the valve change to green, to close the valve, press the “Close” button. The valve will change to grey.

With the “Main” button you can return to the main window.

Figure 7 How to change a regulating valve

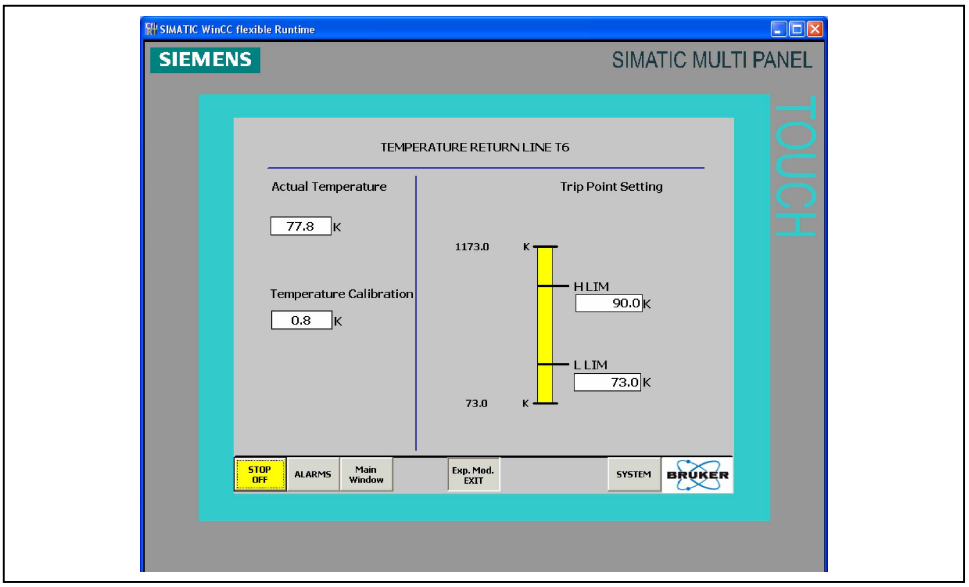


To open/close the valve to a specific level press in the right box, fill in the value and press enter. The valve will be set to the corresponding level.

To open or to close the valve fully, press the open or the close button. The valve will then be opened or closed fully.

With the “Main” button you can return to the main window.

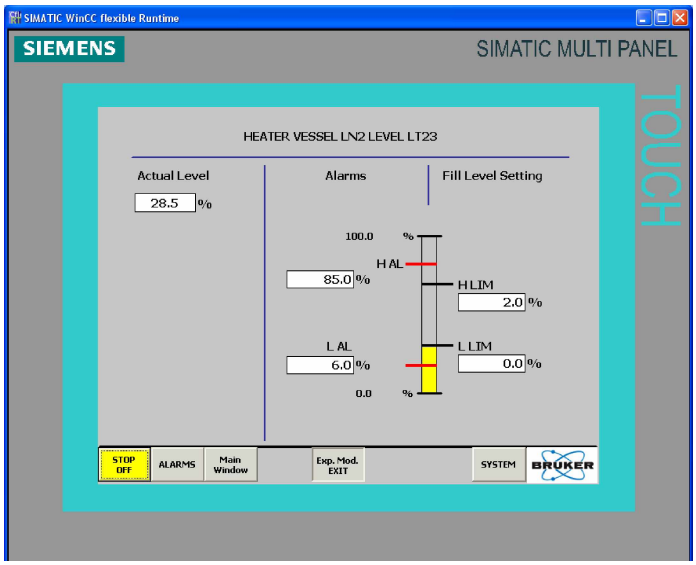
Figure 8 How to change the temperature return line limits



To change the temperature limits in the Temperature Return Line T6 window press the high limit (HLIM) or low limit (LLIM) box and type the required temperature value and press enter.

With the “Main” button you can return to the main window.

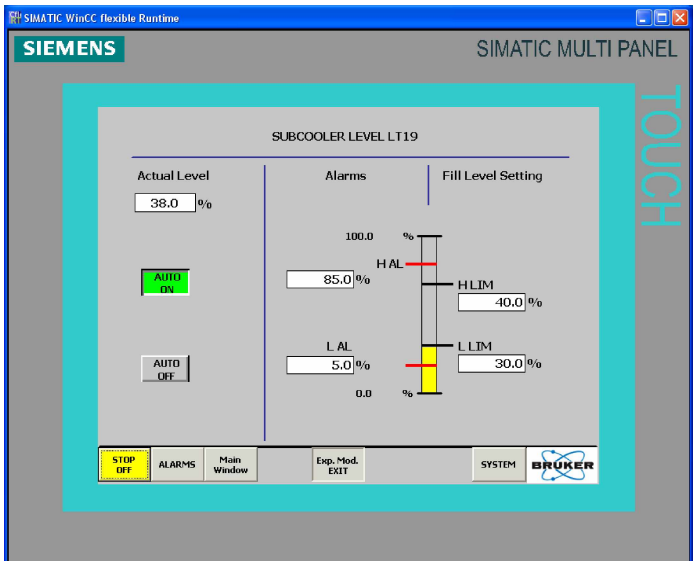
Figure 9 How to set the heater vessel settings



To change the fill level in the heater vessel LN2 Level LT23 press the high limit (HLIM) or the low limit (LLIM) box and type the required fill level and press enter.

With the “Main” button you can return to the main window.

Figure 10 How to set the Sub-Cooler level settings

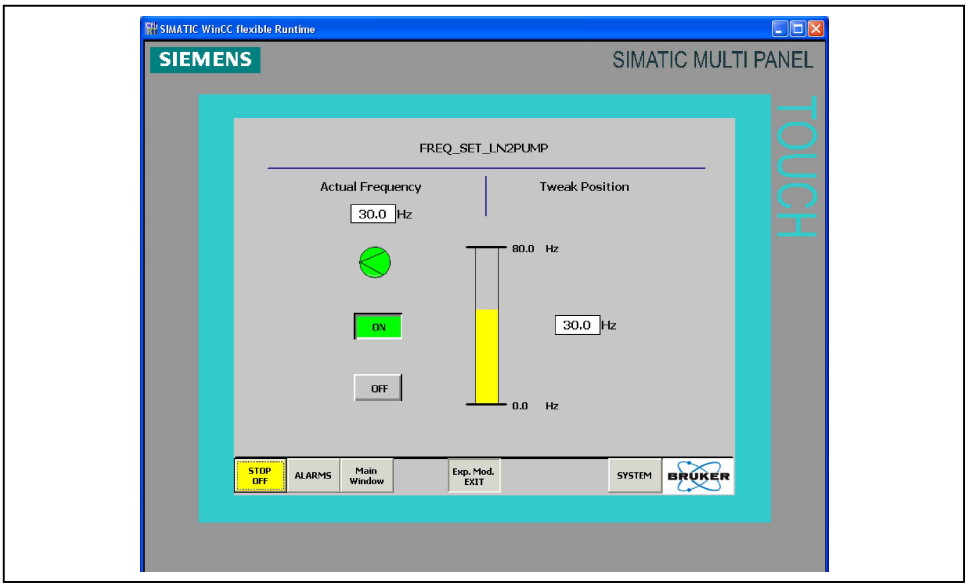


To change the fill level in the Sub-Cooler LT19 press the high limit (HLIM) or the low limit (LLIM) box and type the required fill level and press enter.

To fill the Sub-Cooler automatically press the “Auto-On” button. The button will change to green. To switch the auto-fill of press shortly the “Auto-Off” button.

With the “Main” button you can return to the main window.

Figure 11 How to set the pump frequency

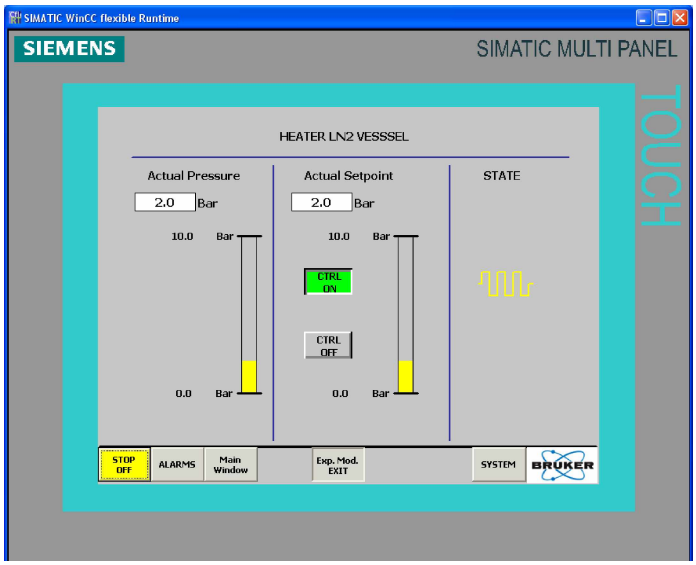


To set the pump frequency press the box on the left side, type the required value and press enter.

To switch the pump on press the “On”-button, the button will turn green. To switch the pump off, press the “Off”-button.

With the “Main” button you can return to the main window.

Figure 12 How to set the heater LN2 vessel set point



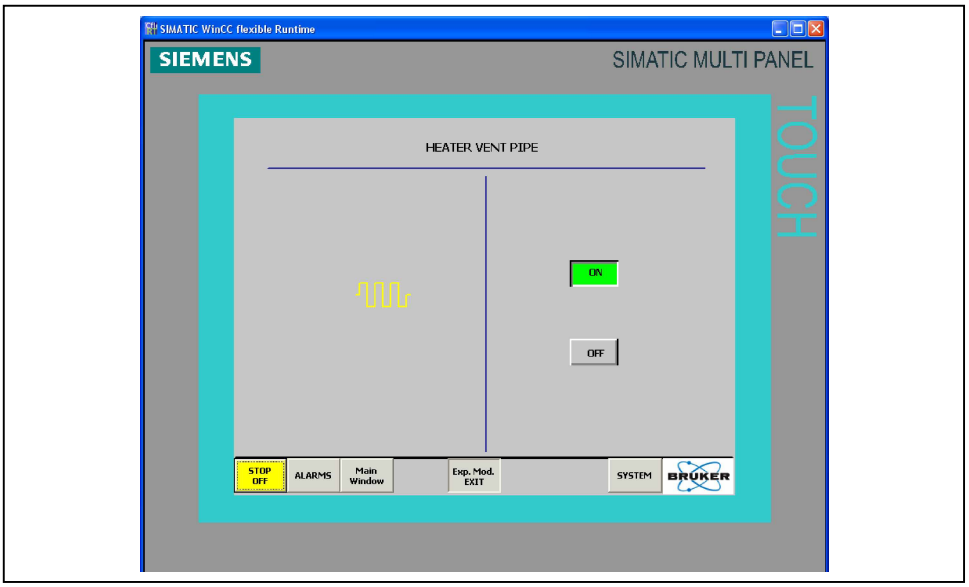
To change the set point of the heater LN2 vessel press the box of the actual set point, type the value and hit enter.

To change the control state of the heater LN2 vessel, press either the “CTRL On”- or “CTRL Off”-button. The button will turn green, when active.

When the heater is active the heater symbol will be yellow, an in-active heater is indicated by a blue heater symbol.

With the “Main” button you can return to the main window.

Figure 13 How to switch on/off the heater vent pipe



To switch on the heater vent pipe press the “On”-button on the touch screen. The button will change to green and the heater vent pipe will change to yellow.

To switch off the heater vent pipe press the “Off”-button on the touch screen. The heater vent pipe will change to blue.

With the “Main” button you can return to the main window.

3. Assembly of the Cryo-Cooler

3.1. Unloading and installation of the Cryo-Cooler

Check the Cryo-Cooler for transportation damages after unloading and dispose packing material according to local regulation.

The cooler is equipped with wheels so it can be easily transported to the test facility or to the final destination. After unlocking the brakes of the wheels for transportation to the final destination, transport the Cryo-Cooler to its destination in accordance with the equivalent chapter of the instructions of the manual of CRYOTHERM.

Caution

2 persons are required to move the Cryo-Cooler safely. Lock the brakes of the wheels at the final destination.

When the Cryo-Cooler is located at the final position, check for completeness as described in table 1 of chapter 2.1.

3.2. Conditions and requirements for initial operation

3.2.1. Tools and Utilities for initial operation

Cryogenic Liquid

Please make sure you wear gloves and glasses while handling cryogenic equipment. Please follow your local safety regulations, too.

The following utilities are required for installation and operation:

- Permanently installed LN2 supply line or a >500l dewar
- Compressed air, 5 bar, inner Ø xmm
- Compressed nitrogen gas, 2 bar, DN 25KF
- 230V 50/60 Hz (+5%-10%) Main Power supply, single phase

3.2.2. Proper connection of tubing

To make sure the system will work properly, please check that all the nitrogen lines are connected properly.

Figure 14: Tubing of closed loop Systems up from serial number 55081

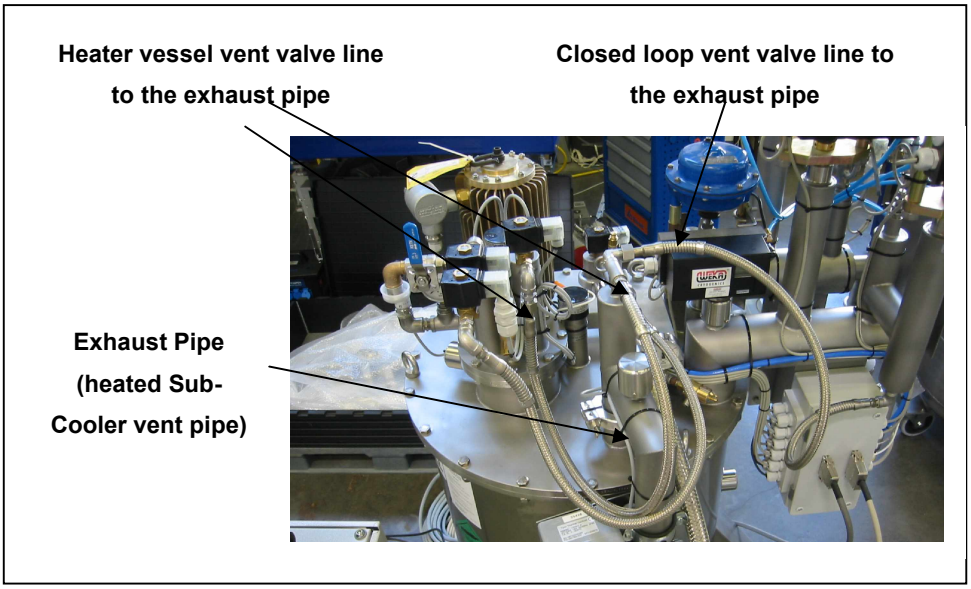
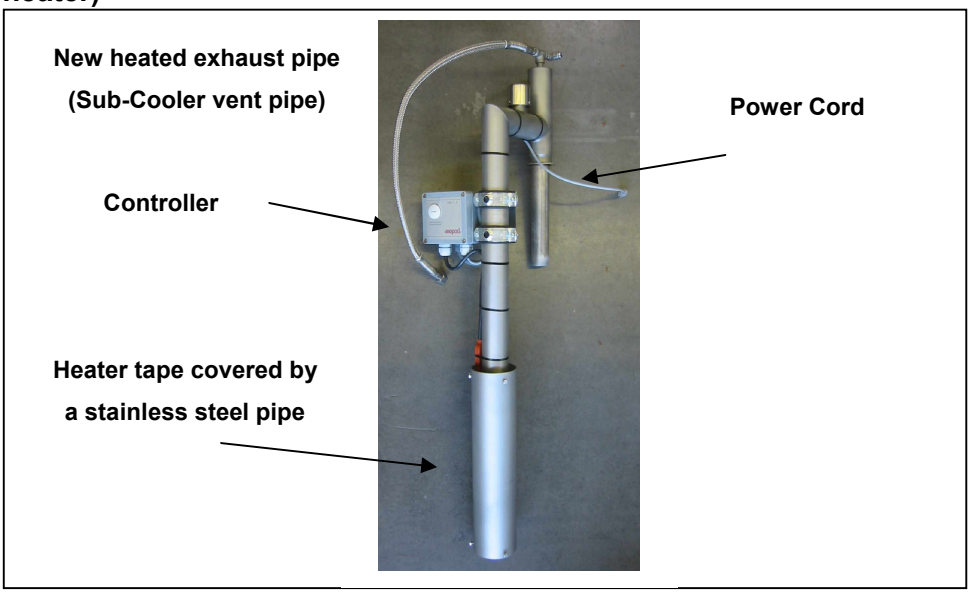


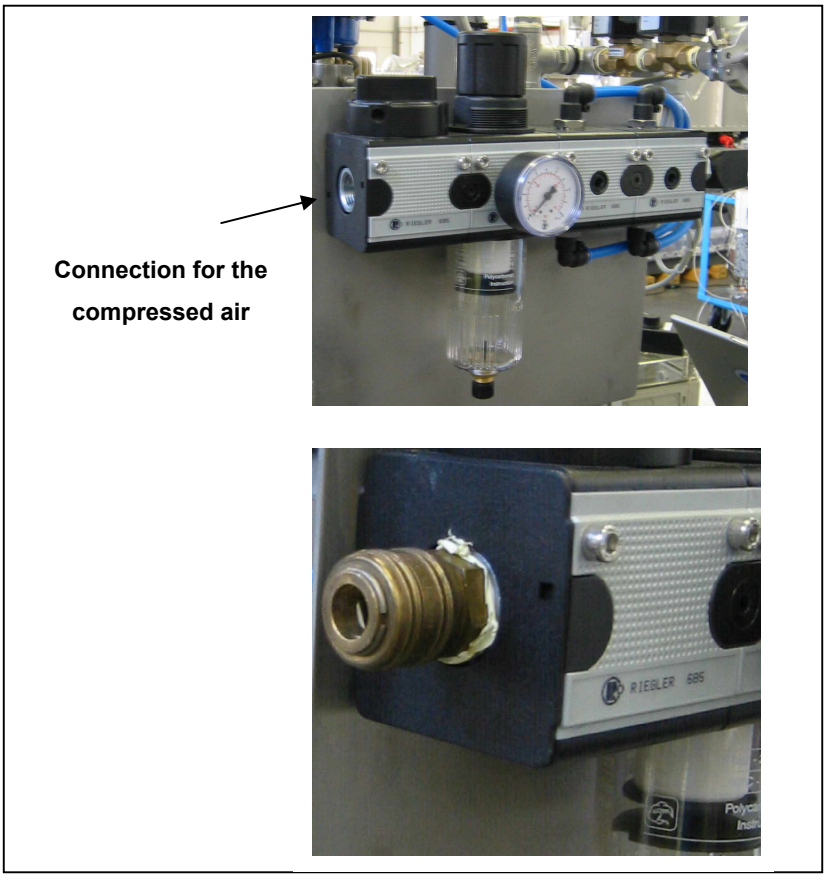
Figure 15: Details of the protection of the exhaust heater (vent pipe heater)



3.2.3. Connecting the compressed air

The compressed air will be connected at the left hand side of the manifold. (See Figure 16: Manifold and the connection for compressed air). The compressed air supply connection is equipped with ¾" threads. It will be equipped at Bruker ASC with a quick connector to mount a flexible tube. Set the air pressure to 5 bar. A tubing inner diameter 9 mm can be used to connect the air supply.

Figure 16: Manifold and the connection for compressed air



3.2.4. Connecting the transfer lines

The transfer lines are equipped with Johnston couplings. These couplings connect the DCM with the Cryo-System. Please refer to the instructions of the manufacturer CRYOTHERM to handle the Johnston couplings properly. The following is just a brief description how the connection could be realized.

The Johnston coupling consists of 5 parts. (See Figure 17) The seal at the cold end is made of Teflon. The seal is not symmetric at both sides. One side is bevelled and one side is recessed. (See Figure 18: Pictures of the bevelled and the recessed side of the O-Ring) To mount the gasket properly, the bevelled side should point towards the male part of the Johnston coupling. Please mount the O-Ring and the clamp as shown on Figure 19: Mounting and Clamping Sequence picture A, B and C. Tighten the nuts carefully.

Connect the transfer lines to the consumer as described in Figure 19: Mounting and Clamping Sequence. Make sure, that the gaskets of the couplings are in the right position so that there is no nitrogen leakage and that the bending radius of the transfer lines is smaller larger than 400mm.

Danger: Cryogenic Liquid

Make sure no remaining liquid nitrogen is in the transfer lines while opening the flanges. Please make sure you wear gloves and glasses while handling cryogenic equipment. Please follow your local safety regulations, too. In case overpressure is in the system please open V17 or V20 to relieve the overpressure.

Before continuing with the next chapter it is advised to perform a leak tight test and a pressure-resistant test up to the specified Cryo-Cooler pressure.

Figure 17: Brief description of the Johnston coupling

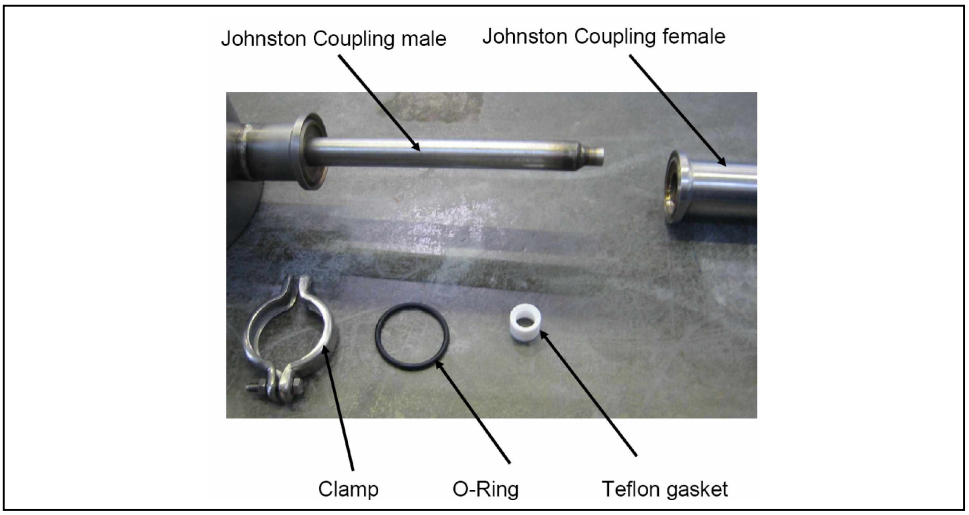


Figure 18: Pictures of the bevelled and the recessed side of the O-Ring

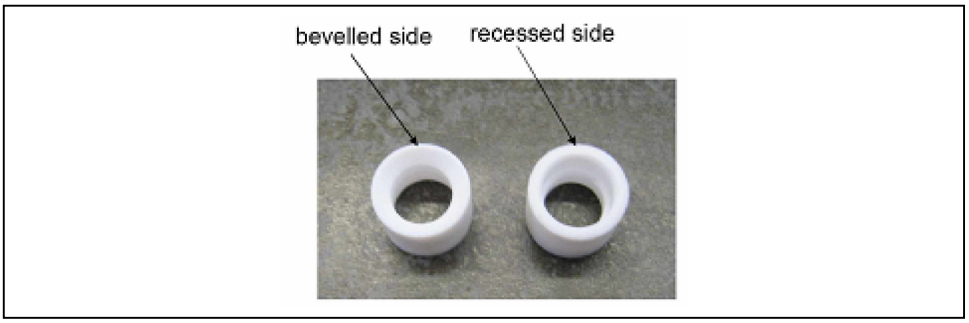
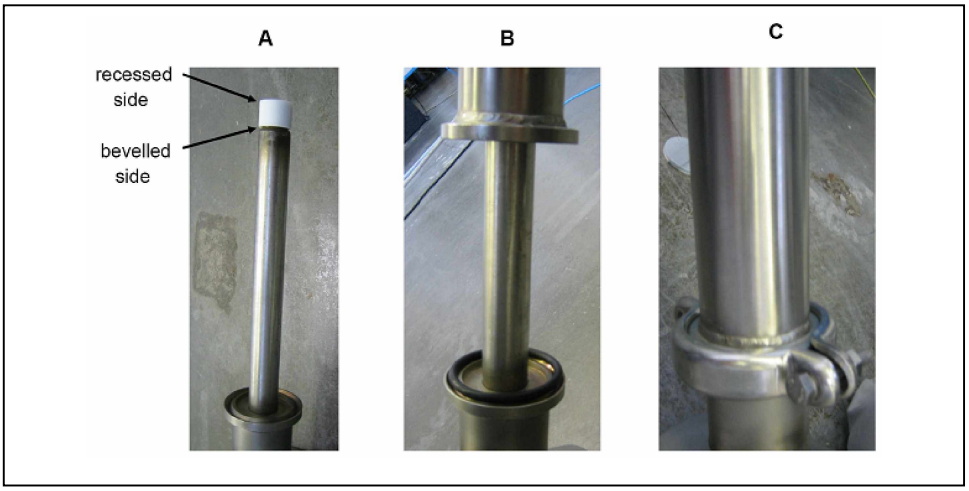


Figure 19: Mounting and Clamping Sequence



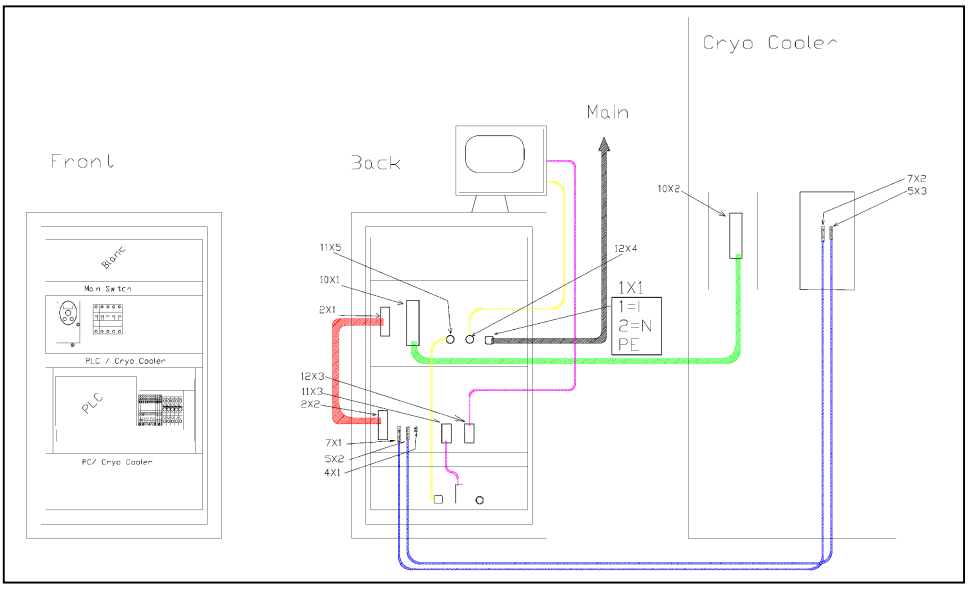
3.2.5. Connecting the control system:

Danger: Electricity

The control system should be connected and powered up by a qualified electrician.

In Figure 20 you find an overview of the connections between the Cryo-Cooler and the control rack and a description with the explanation of the connections.

Figure 20: Schematic of electrical connections



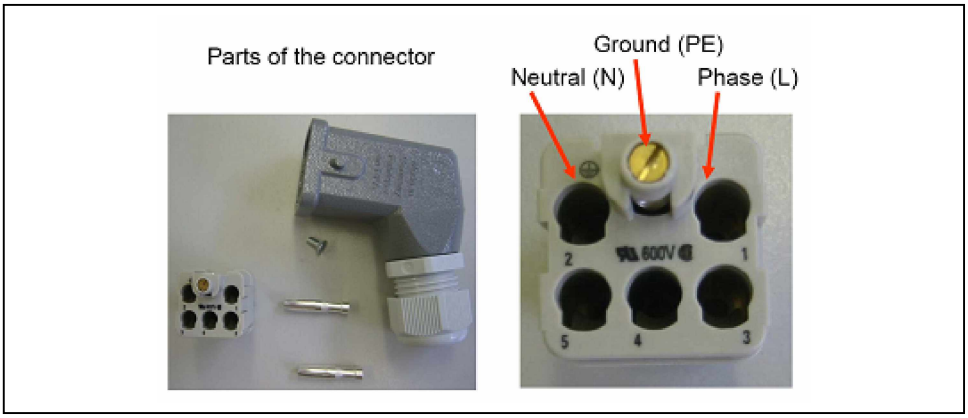
!Überarbeitung des Textes nach neuer Graphik!

The main connector (plug and socket supplied) is located inside the rack on the backside of the large 19” crate. The parts of the connector are inside a bag at the backside of the rack. The socket is labelled 1 X 1. For details about the connector please see Figure 21 and table 2)

In case the main power is connected to the rack already, please feel free to connect the cables between the control rack and the Cryo-System prior to

turn on the power. All electrical connectors cannot be interchanged since they are all of different types and sizes.

Figure 21: Detailed view of the part of the connector



3.3. How to prepare the system for commissioning

Before starting with the commissioning please check, that:

- Both temperature readings show ambient temperature
- both pressure readings of the closed loop show zero bar for atmospheric pressure to make sure the sensors work properly

After checking the conditions please:

- Open and close each valve to check if the system is ready for commissioning

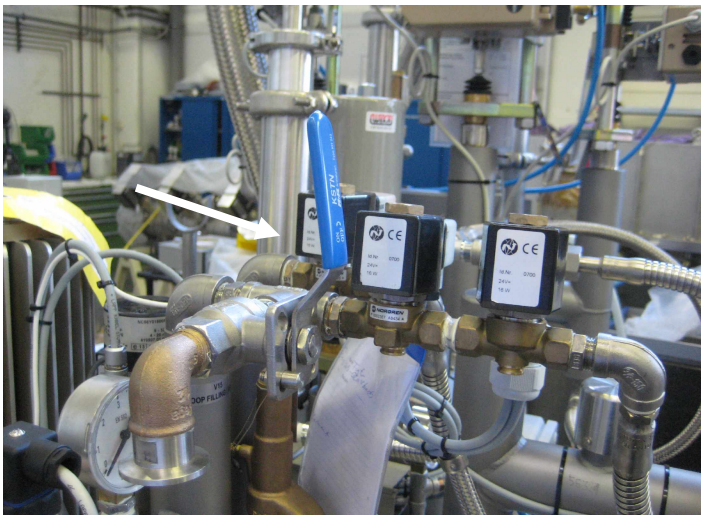
If the temperature, pressure and valve conditions are ok, the Cryo-Cooler is ready for commissioning.

3.3.1. Evacuation of the Cryo-Cooler and the closed loop system

The evacuation of the system is mandatory before start filling the closed loop with liquid nitrogen when it was shut off for several weeks or completely emptied.

To evacuate and vent the system connect a T-Piece to the manually operated ball valve shown in Figure 21. Connect a vacuum pump to the one flange of the T-Piece and dry nitrogen to the other.

Figure 22: Which ball valve to be opened manually during purging the closed loop



Now close all valves and leave only V9, V10 and V11 open.

Now evacuate the lines for at least 30min, switch of the pump after 30min and flood the lines with dry nitrogen.

Repeat the evacuation and filling procedure 3 times to make sure no air is trapped inside.

3.3.2. How to purge the closed loop with dry nitrogen

The sequence for the nitrogen purge of the Cryo-Cooler is as following:

(1) Set the pressure reducer of the nitrogen supply gas to <3 bar, min 1 bar.

(2) Close all valves

(3) Connect the dry nitrogen to valve V21 (See Figure 23 purge port)

(4) Now open V9, V10, V20 and V21 fully

(5) Purge for 30min

(6) Close V9, open V11

(7) Purge for 15min

(8) Close V11

(9) Open V17

(10) Purge again for 15min

(11) Close all valves

Figure 23: Overview of the purge ports

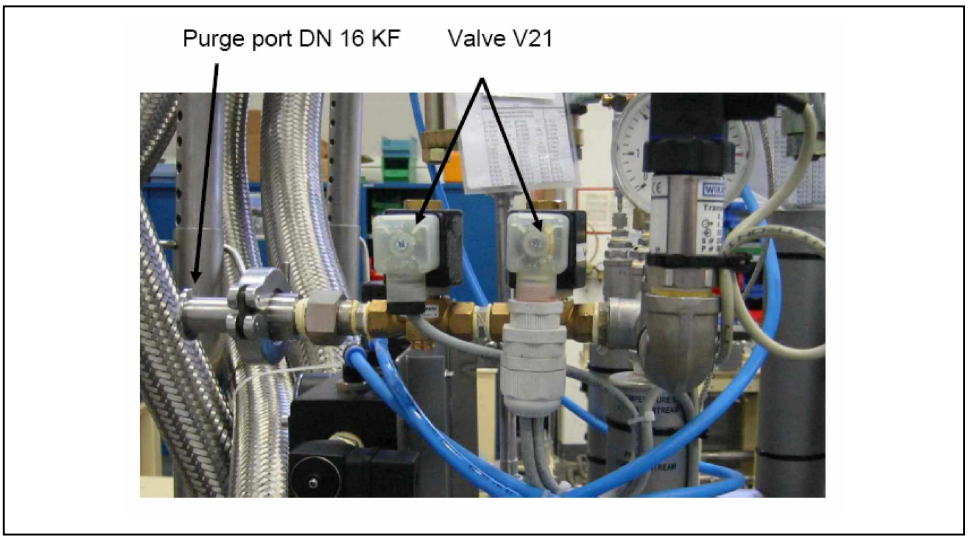


Figure 24: Which pressure gauge to be looked at during purging the closed loop

3.3.3. Check for leaks

Pressurize the system by opening V9, V11, V10 and V21 with dry N2 up to 3 bar. Check for a possible pressure drop. The pressure should stay stable for at least 1 hour. (No indicated pressure drop on the gauge)

3.3.4. Nitrogen gas connections

For a save operation of the system the nitrogen supply lines should always be connected at V21 and at the ball shown on Figure 22.

Danger: Cryogenic Liquid

Do not open V21 or the manual ball valve shown on figure 18 in case the closed loop or the heater vessel is pressurized and LN2 is in the systems. LN2 may splash into the area. Please make sure you wear gloves and glasses while handling cryogenic equipment. Please follow your local safety regulations, too.

3.3.5. Turn on the exhaust heater

During the operation of the system in particular with heat load, a lot of liquid nitrogen will be evaporated. It leaves the system by the exhaust pipe. This cold nitrogen gas might cause icing at the exhaust of the pipe. Therefore the pipe is heated. Turn on the heater using the touch panel. The exhaust pipe is equipped with a heater wire.

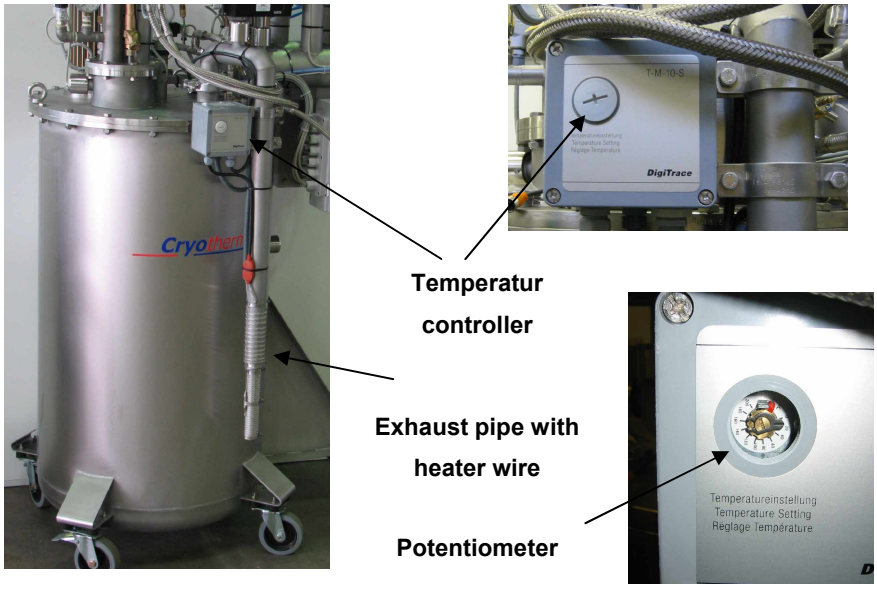
Warning: Hot surface

In case the temperature controller does not operate properly, temperatures up to 200°C can be achieved at this location.

The temperature at the heater wire can be adjusted at the temperature controller of the exhaust pipe. (See Figure 25)

Remove the large plastic screw labeled “temperature setting” and adjust the temperature set point to 10 to 20°C. For safety reasons, never set a temperature above 40°C.

Figure 25: Where to adjust the temperature



3.3.6. Connect the LN2 to the Cryo-System

Connect the local LN2 supply (Dewar, ring line, etc.) to the interface at the Cryo-Cooler. The pressure in the ring line should be >1bar and <4bar. Before connecting, please make sure the supply line is dry and purged with nitrogen gas.

Danger: Cryogenic Liquid

The cryogenic liquids used to cool down the equipment could severely damage persons. Appropriate safety equipment for handling cryogenic liquids has to be provided by the operator. Please make sure you wear gloves and glasses while handling cryogenic equipment. Please follow your local safety regulations, too.

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4. Operating the Cryo-Cooler

4.1. The Stop/Off Functions

4.1.1. The Stop Function

In order to bring the Cryo-Cooler into its default state (i.e. all valves closed, V10 100% open, LN2 pump off, pressure off) press shortly (< 1 sec.) the Stop Button.

The Stop Function becomes active in case an alarm trigger is activated.

The ready signal for the beamline interlock will be disabled.

Warning: Over pressure condition

In case the stop function is active, the consumer is isolated. The liquid nitrogen in the transfer lines and the consumer will warm up by itself and overpressure might activate the pressure safety valves of the closed loop and/or the heater vessel. It will be blown into the surrounding atmosphere.

4.1.2. The Off Function

To Activate the Off Function press the Stop-Button for > 2sec. The Off Function is similar to the Stop Function, but additionally the release valves V17, V20 will be opened. These valves are opened to prevent over-pressure.

4.2. Operating the Cryo-Cooler in expert mode

The operating conditions of the closed loop system depend on the pressure drop at the consumer and the power absorbed by the fluid in the optical element.

4.2.1. Description of the manual procedures

4.2.1.1. How to fill the Sub-Cooler

For filling the Sub-Cooler, please be aware of, that:

- An integrated high level alarm prevents an overfilling of the Sub-Cooler. This alarm is set to 94% filling level.
- In addition the expert can set a high limit value. Make sure this value is set to value smaller than the alarm level of 94%

To fill the Sub-Cooler:

1. Open V19
2. The filling stops by closing V19 or if the level reaches the high limit value.

It will take a few minutes until liquid nitrogen enters the system!

After 10 - 15 minutes you will notice the first indication at the filling level at the level indicator of the Sub-Cooler.

Fill the Sub-Cooler to at least 15%

Danger: Risk of suffocation

Ensure that the ventilation system of the building is sufficient to avoid oxygen deficiency. Install an oxygen deficiency warning system if required.

4.2.1.2. How to fill the heater vessel

To fill the heater vessel do the following steps:

- Open valve V19 for 30 seconds

- Close valve V19
- Open valve V15
- Open valve V20

It might take 5-10 minutes until the level increases.

- If the desired level is achieved, close V20 and V15 again.

4.2.1.3. How to cool down the component

Caution

Read the full chapter prior to start the filling of the closed loop. This chapter contains important information to make sure you will successfully cool down the closed loop.

Before proceeding with filling the closed loop system do the following checks:

- Make sure the Sub-Cooler is filled at least 15% or start filling the Sub-Cooler.
- Make sure the closed loop has been purged.
- Turn on the exhaust heater
- Make sure Valves V9 V10, V11, V15, V 17, V19, V20 and V21 are closed.
- Make sure the LN2 supply is connected to the supply line and under pressure (≈1-4 bar)
- Make sure the pressure control is turned off

After the checks proceed as described in the following (during the cool down process always check the filling level in the heater vessel. If it drops below 40% refill it to 90%):

(1) Set V10 to 60%.

(2) Turn on the liquid nitrogen pump and set frequency to 30 Hz.

(3) Open V19 for at least 60 seconds to make sure no air is in the supply line.

(4) Fill the heater vessel to 90%

(5) Open V9

(6) Open V17 fully (100%)

(7) Check if the Bypass valve is set to 60%

In case the nitrogen level in the heater vessel drops below 40 % please refill to 90%.

Warning: Risk of over pressure condition

There is a chance of an over pressure condition and pressure relieve valves will open. This condition is caused by the amount of evaporated liquid nitrogen gas.

Caution: Stop Function

In case the filling level of the heater vessel drops below 5 % the stop function becomes active. (See chapter 11.1 for details) In this case V9, V11 will be closed and V10 will be opened fully. After a refill of the heater vessel, please make sure you open V9, V11 and V10 to 60% again.

---

(8) Wait until the temperature T6 in the return stream indicates a temperature below 200 K. Close V17 to 35% and open V11 fully

(9) Wait until the temperature T6 in the return stream indicates a temperature below 90 K. Close V17 fully

(10) Wait until the temperature in the return line indicates a temperature below 82 K

(11) Turn on the pressure control and set the operating pressure (recommended: 2 bars). Wait until the set pressure is reached for the first time.

Adjusting the proper filling level!

(12) If the filling level inside the heater vessel is higher than 30%, open V17 by 30%. If the filling level is lower than 25%, then refill the heater vessel to 45% and open V17 to 30%

(13) Wait until the filling level inside the heater vessel reaches 30%

(14) Close V17.

Now the system switches into the ready state (indicated by “system ready” turning green). It might take up to 6 hours until the pressure gets stable within ± 10 mbar.

4.2.2. Correct pressure in the closed loop

The closed loop system works with one phase sub cooled liquid nitrogen. The temperature in the back stream (T6) of the loop must be below the boiling point of liquid nitrogen. (Table 3 shows the boiling points of liquid nitrogen at 0-5bar)

Table 3: Table of Overpressure and Temperature

Overpressure		Temperature	
(bar)	(PSI)	(K)	(°C-)
0	0	77	-196
1	14,5	84	-189
2	29	88	-185
3	43,5	91	-182
4	58	94	-179
5	72,5	96	-177

The pressure in the loop should be set to a higher value (+ 1 bar, 22 PSI) than required to be sure that no bubbles will appear. The LN2 consumption of the system rises with higher pressure. The pressure PT1 shall be at least

0.5 bar below the opening pressure of the safety valve (5 bar, optional 10 bar).

4.2.3. Adjusting the flow rate (Pump Frequency)

The cooling power of the closed loop can be controlled by the flow rate (pump frequency). High flow rate means high cooling power and lower LN2 temperature in the loop. The pump frequency can be varied from 0 to 80 Hz. The flow rate (pump frequency) should only be set as high as really required because the LN2 consumption of the Cryo-System increases and the pump lifetime decreases at high frequency operation.

4.2.4. Standard operating parameters without additional heat-load

- V10 open at 60 %
- V11 open at 100 %
- Pressure set point: 2 bar
- Pump Frequency: 30 to 50 Hz
- Heater vessel filling level: 25 – 30 %
- Liquid Nitrogen consumption without thermal load 3 l/h. (plus nitrogen consumption caused by the heat load generated by the DCM)

4.2.5. Adjusting/Correction of the level in the heater vessel

After a long time operation (more than 4 weeks) a refill of the heater vessel might be necessary. A refill is necessary if the filling level drops 10 % below the set value for the heater vessel.

4.2.5.1. Decrease the liquid nitrogen level in the heater vessel

To reduce the liquid nitrogen level, please proceed as follows:

- Open valve V17 to 35 %
- Go back to the main menu

If the desired filling level is achieved, close V17.

4.2.5.2. Increasing the liquid nitrogen level in the heater vessel

To increase the liquid nitrogen level, please proceed as follows:

- Turn of the pressure control
- Fill the heater vessel to required level + 20 % (refer to Chapter 4.2.1.1)
- Turn on pressure control
- Wait until set point is reached
- Release LN2 as described in Chapter 4.2.5.1.

4.2.6. Automatic refill of the Sub-Cooler

The control system is equipped with an automatic refill function. This function will automatically fill the Sub-Cooler once the minimum filling level is achieved. If this function is active, a manual refill is not necessary anymore. To enable the automatic refill function, press the touch panel at the position filling level control. (See Figure 5)

The recommended filling level is 30 to 40%. The maximum filling level should be set to 40%. The minimum level should be set to 30 %. These filling level settings make sure you will have sufficient liquid nitrogen in the system to operate 5 to 10 hours in case no liquid nitrogen is available for a refill.

Attention: In case the set value for the maximum filling level is by accident lower than the real filling level, you will not be able to open V19.

4.3. Isolating the consumer / warming-up of the consumer

To warm up the consumer it is possible to separate the consumer cooling from the Cryo-System.

To do so please proceed as described in the following:

- Connect dry nitrogen gas to V21
- Press the stop button (V9 closes; V11 closes; V10 opens fully) shortly < 1 sec
- Open V17 by 40 %.
- Turn on the pump again to 30 Hz
- Open V21 after the pressure PT1 < 1 bar
- Wait until the temperature T6 increases to 95 K (This might take up to a few hours, depending on the consumer)
- Open V17 fully
- Purge with dry nitrogen gas until each component of the system reaches ambient temperature
- Close V21
- Close V17

It is possible to disconnect the transfer lines now.

4.4. Operating the Cryo-Cooler in Operator Mode

4.4.1. Description of the automatic procedures

Within the new GUI the automatic functions have been introduced. These automatic functions will operate the valves individually and do not need operator intervention. See chapter 2.4.1 how to login and operate the automatic procedures.

Basically 3 functions are available:

- Automatic cool down
- Automatic warm up
- Automatic refill of the heater vessel

All 3 functions are explained in the following chapters in detail.

The automatic procedures can be aborted by hitting shortly the stop button (< 1 sec.)

4.4.1.1. Automatic cool-down

The automatic cool down procedure enables a cool down of the consumer component without the interaction of the operator.
Prior to the selection of the “Automatic Cool Down”, the following status of the system has to be achieved:

- A full liquid nitrogen dewar or a liquid nitrogen ring line has to be connected to the closed loop system.
- The Sub-Cooler should be filled to at least 15% and automatic refill has to be turned on.
- The transfer lines and the consumer have to be purged with dry nitrogen to make sure there is no trapped air inside the closed loop

During automatic cool down:

- The exhaust heater will be turned on.
- The heater vessel will be filled with liquid nitrogen.
- The consumer component will be cooled down to 78 K.
- The correct filling level inside the heater vessel will be adjusted.
- The pressure control will be turned on.
- A ready signal will be generated.

4.4.1.2. Automatic warm-up

The automatic warm-up procedure warms the consumer up to ambient temperature and maintains the closed loop Cryo-Cooler ready for the next cool down procedure.

Prior to use the automatic warm-up procedure, the closed loop system should be in a closed loop operation and the consumer is cooled by liquid nitrogen.

Make sure dry N2 is connected to V21 > 1bar.

In case the automatic warm-up is selected, the following action will be executed:

- Forward and return valve (V9 and V11) will be closed
- Valve V17 will be opened to a certain extend
- As soon as the pressure in the transfer lines and the consumer is below 1 bar, V21 opens
- The system will be purged and warmed-up until the return temperature T6 achieves 280 K.

Caution

Please make sure a nitrogen compressed gas line is connected to the purge port at V21. Otherwise liquid nitro-gen might leave the system.

4.4.1.3. Automatic refill of the heater vessel

In case the heater vessel filling level drops below 20 % after a long time of operation, it makes sense to refill the heater Vessel to 25% for best performance.

Prior to operate the automatic refill, please make sure:

- A liquid nitrogen dewar with a filling pressure of 1-4 bar or a ring line with a pressure of 1-4 bar is connected to the cryo system.
- If needed, close the shutter to the beamline since there will be pressure oscillations inside the liquid nitrogen circuit. In case the system is not sensitive to pressure oscillations inside the liquid nitrogen circuit, please feel free to continue operation.

The auto refill will execute the following actions:

- Turn off the pressure control
- Open V15
- Open V20 for a second
- Close V20 for a second
- V20 will continue to open and close until the proper filling level is achieved.
- Turn on the pressure control

4.5. Shut down of the Cryo-Cooler

4.5.1. Turn off procedure of the system

Bring the Cryo-Cooler into the Off-Mode b pressing the Stop-Button > 2sec. The system is now turned off and can warm up safely on its own. To accelerate the warming up of the closed loop you can purge the system as described in chapter 3.3.2 or by the automatic warm up, see chapter 4.1.1.2.

4.5.2. Draining of the Sub-Cooler

The following actions are necessary to make sure no overpressure in the closed loop system will be generated during draining of the Sub-Cooler:

- Isolate the consumer as described in chapter 4.3
- Open V20 to release the pressure in the heater vessel
- Open the ball valve when PT3 < 0,1 bar, close V20

Use a drain pipe as shown on Figure 26 and install this pipe instead of the exhaust heater mounted at the Sub-Cooler (See Figure 15). To remove the exhaust pipe shown on figure 6 please remove the flexible tube coming from the closed loop vent valve and the flexible tube coming from the heater vessel vent valve. Disconnect the electrical connector of the heater. It is hidden underneath the cable tray. (See Figure 27)

Compressed dry nitrogen gas and an empty separate storage dewar are required to drain the liquid nitrogen of the Sub-Cooler into a suitable storage dewar.

Connect the compressed nitrogen to the drain pipe and set the pressure regulator to 1 bar.

- Open the valve at the drain pipe and supply the compressed nitrogen to the Sub-Cooler.
- Drain the system for 12h to release the LN2 and also the cold N2 out of the Sub-Cooler.

Danger: Cryogenic Liquid

The cryogenic liquids coming out of the drain pipe could severely damage persons. Appropriate safety equipment for handling cryogenic liquids has to be provided by the operator. Please make sure you wear gloves and glasses while handling cryogenic equipment. Please follow your local safety regulations, too.

Figure 26: Drain Pipe

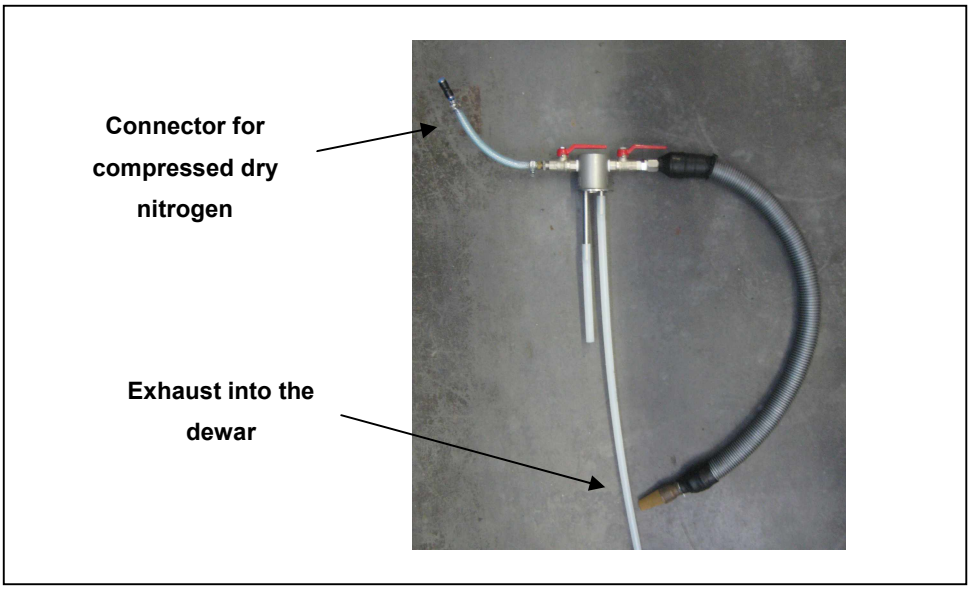
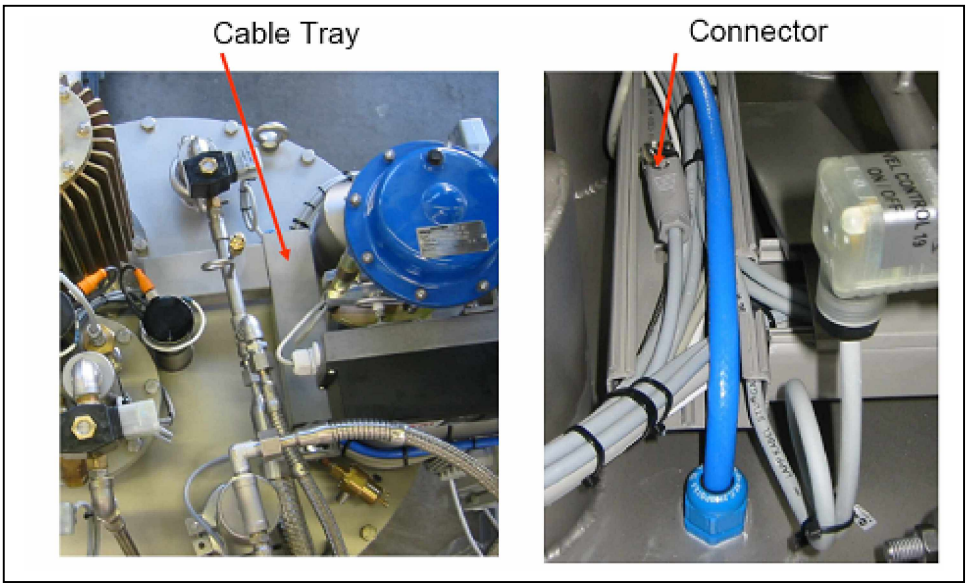


Figure 27: Position of the electrical connector, hidden underneath the cable tray



4.5.3. Draining the heater vessel

Drain the Sub-Cooler first. (See section 4.5.2) The draining of the heater vessel system requires dry nitrogen for purging. Connect a tube DN25KF to the manually operated ball valve. (See Figure 28) This ball valve is connected to the heater vessel.

Make sure:

- The pressure control (heater) of the heater vessel is turned off.
- The liquid nitrogen pump is turned off.

To drain the closed loop, proceed as follows:

- Open the manually operated ball valve
- Open V20, V10 100%
- Purge for at least 6h
- Hit the Stop-Button
- To prevent the system from Humidity pressurize the heater vessel with approx. 0,5 bar N2
- Close the ball valve

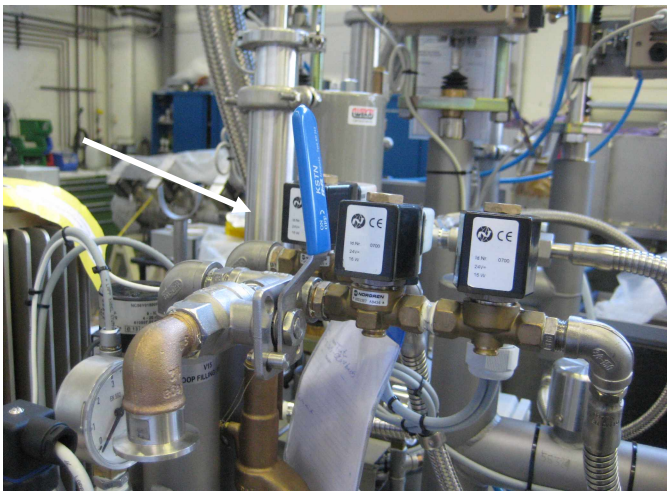
The system is ready to turn off the electrical power and to disconnect the transfer lines for packaging.

Danger: Cryogenic Liquid

Make sure no remaining liquid nitrogen is in the transfer lines while opening the flanges. Please make sure you wear gloves and glasses while handling cryogenic equipment. Please follow your local safety regulations, too.

In case overpressure is in the system please open V17 or V20 to relieve the overpressure.

Figure 28: Which ball valve to open manually



5. Troubleshooting

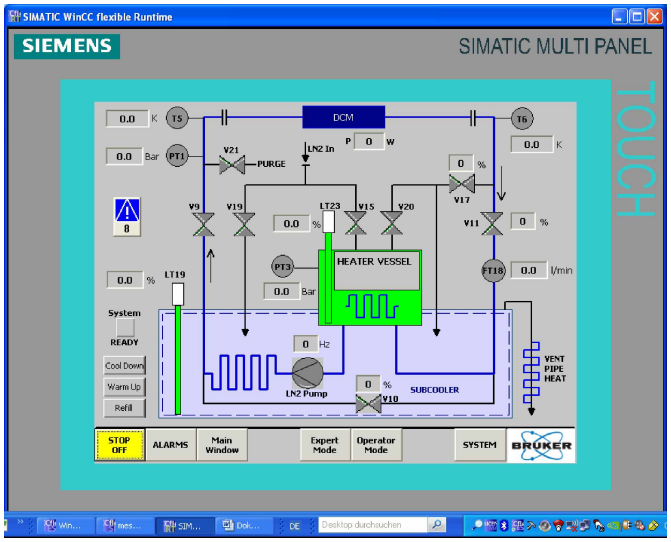
5.1. Warning and Alarms

In case operating parameters are out of range the system generates a warning or the stop function becomes active automatically under certain circumstances.

A warning or alarm will be indicated at the touch screen. (See yellow arrow in Figure 29) The number of all current warnings and alarms is shown below the warning sign (see figure 32)

To see details of the alarm, please press the alarm button at the touch screen. (See red arrow in figure 32)

Figure 29: Where to find warning and alarms



Once the alarm button is activated a second window will open up which provides the history of warnings and alarms. Please note, that not all

warnings and alarms are necessarily indicating an actual problem as the history logs al occurred warnings and alarms since the last clearance.

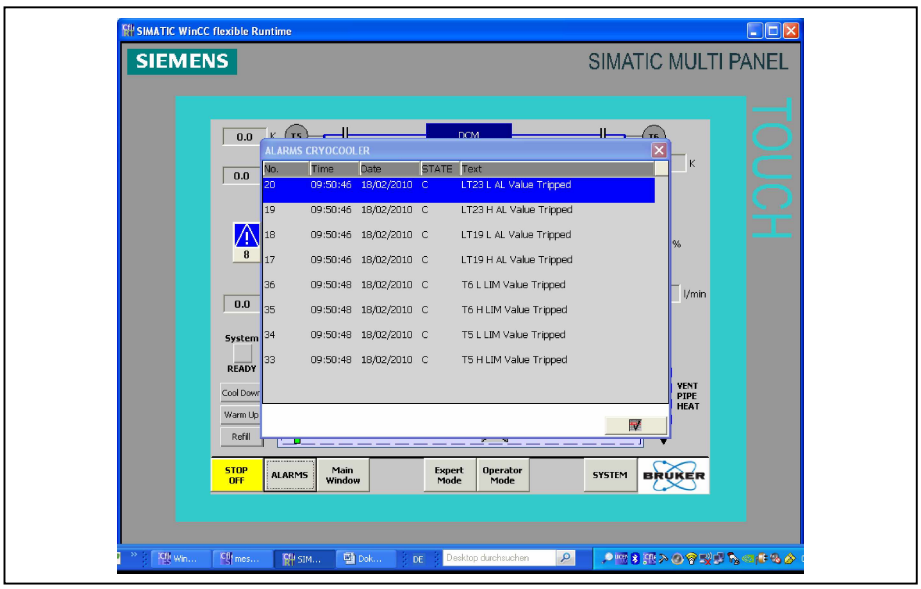
To see only the currently valid warnings and alarms, clear the history by pressing the Quit-Button.

The description for the warning and alarms is briefly explained in the text field (showing also the time stamp) related to the parameter the caused the failure.

Prior to be able to reset a warning or an alarm, it is necessary to fix the related problem. The root cause for the faulty condition is indicated in a clear text related to the parameter that caused the failure condition.

After the faulty condition is solved, the warning or alarm can be cleared by hitting the Quit-Button in the alarm window.

Figure 30: Example Overview of warnings



Caution: Experts required

Some components of the Cryo-System require electricians or persons familiar with pneumatics. Please make sure only well trained persons familiar with the repair of these components will execute the repair.

Please feel free to contact Bruker ASC if you cannot solve the problem easily.

5.2. Icing on tubing or at the outside of the Sub-Cooler vessel

Ice on vacuum insulated tubing or the Sub-Cooler indicates a leakage or a loss of insulation vacuum. Please contact Bruker ASC for an evacuation or a leak check of the related tubing.

Caution: Failure situation:

In case you will find ice on vacuum insulated tubing or at the outside of the Sub-Cooler, please turn off the Cryo-System and make sure it warms up safely as described in section 10.1.

5.3. Temperature does not drop during cool down

In case the temperature indicated at T5 does not drop down within 30 minutes, and the cool down procedure has been executed as described in section 3.3.2, please open V17 60 % until the temperature indicated at T5 starts to drop down.

5.4. Valve V19 does not operate

5.4.1. Automatic refill operation

In case the set value for maximum filling level is by accident lower than the real filling level, you will not be able to open V19. Even if automatic refill is

off you will not be able to open V19 if the real filling level is higher than the trigger value of the maximum filling level.

5.4.2. Icing on V19

Icing at the outside of V19 occurs during normal operation since there is no vacuum insulation. Icing inside the valve might block the valve operation. Do not remove the feed line from the liquid nitrogen supply if the feed line is at cryogenic temperature. Otherwise moisture may enter the feed line and cause icing at the feed valve. This might be the reason for the malfunction.

Possible repair:
Wait until the feed line and the valve is at ambient temperature. Please feel free to use a hot air blower at the outside of the valve to accelerate the warm up.

Caution:

Please make sure you do not damage the insulation of the cables or the housing of the valve while heating. Check if the valve is operational again.

In case the valve operates again at ambient temperature, please connect a dry nitrogen gas line to the fill line. Open V19 and purge the valve for 5 minutes using nitrogen gas.
Connect the dewar again and start filling the Sub-Cooler.

5.5. The Cryo-Cooler does not switch to ready state

If the Cryo-Cooler does not switch to ready state, please check the following conditions:

- V9 Open
- V11 Open

- Pressure Control “on”
- Pressure in the heater vessel has reached the set point
- Nitrogen Pump “on”
- Heater Vessel Filling Level > 20%
- T5 < 80K

If one of these conditions is not fulfilled, the Cryo-Cooler will not switch to ready state.

6. Maintenance & Inspection

Under normal circumstances the Cryo Cooler requires no maintenance or servicing except of the circulation pump. For maintenance of the circulation pump pleas look at the recommending instruction manual in chapter 3.6.2 of the documentation.

If the Cryo-Cooler is not in use for a prolonged period, it will gradually warm up to ambient temperature. This causes moisture to condense on the cold container surface of the inner shell and tubes if they are open to atmosphere. This moisture can be removed by purging the container with dry nitrogen gas at room temperature.

If the Cryo-Cooler should be rendered unusable as a result of breaking the vacuum or another reason, it is advisable to return the container to the manufacturer for inspection and possible repair.

Bruker ASC advises to perform the following test/maintenance procedures once per year. These tests shall be carried out by a trained and qualified personnel familiar with cryogenic equipment.

6.1. Inspection of the Cryo-System under normal conditions (i.e. the closed loop is cooled down)

6.1.1. Pressure control test of the closed loop

To control the pressure of the closed loop, bring the closed loop in the following conditions:

- Pump 40%
- Open V10 to 60%
- Open V11 to 100%
- Set the pressure control to 2 bar
- Fill the heater vessel to 30%
- Wait for 12h to stabilize the system

- There should be no change in the PT3 reading on the display over a timeframe of 1h

The pressure control test should result in a pressure stability of ±10 mbar.

6.1.2. Leak-test of the closed loop system

To perform the leak-test, do the following steps:

- Note the LT23 level
- Wait 12h, note LT23 again
- Average deviation should be < 1-2%

6.1.3. Automatic restart test

This test simulates a power failure and makes sure the system powers up again safely into its normal operating conditions.

To perform the automatic restart test, perform the following steps:

- Switch off the main circuit breaker at the control rack.
- Wait 2 minutes and turn on the power again.

The system should automatically boot and continue its operation using the same parameters as before. In case a failure is observed, please contact Bruker ASC.

6.1.4. Visual Inspection of the Cryo-Cooler

During the visual inspection you should check for

- Icing at the valves and tubing (under normal operation no icing should be visible, only during refill procedure icing should be visible)
- Check for condensed water on top of he Sub-Cooler and heater vessel
- Check for icing at the vent pipe

- Check for visible damage at the Cryo-Cooler, cables and connectors
- Check the LN2 transfer lines for damages, over bending and icing at connections

6.2. Tests to be performed with a warmed up Cryo-Cooler

6.2.1. Leak test w/ consumer

To perform the leak test, perform the following steps:

- Open V9, V11, V10
- Close V15, V20, V19
- Switch the pump off
- Set the pressure control off
- Pressurize the closed loop via V21 with dry N2 up to 3bar
- Close V21 and disconnect the dry N2
- Wait for 6h
- Control the pressure

A good working Cryo-Cooler should have a pressure drop less than 0,1 bar.

6.2.2. Leak test w/o consumer

To perform the leak test, perform the following steps:

- Pressurize the system as described above
- Isolate the consumer by closing V9 and V11
- Open V17 to release the pressure of the consumer line

A good working Cryo-Cooler should have a pressure drop at PT3 of less than 0,1 bar over a timeframe of 6h.

6.2.3. Automatic restart test

This test simulates a power failure and makes sure the system powers up again safely into its normal operating conditions.

To perform the automatic restart test, perform the following steps:

- Switch off the main circuit breaker at the control rack.
- Wait 2 minutes and turn on the power again.

The system should automatically boot and continue its operation using the same parameters as before. In case a failure is observed, please contact Bruker ASC.

6.2.4. Visual Inspection of the Cryo-Cooler

During the visual inspection you should check for

- Icing at the valves and tubing (under normal operation no icing should be visible, only during refill procedure icing should be visible)
- Check for condensed water on top of he Sub-Cooler and heater vessel
- Check for icing at the vent pipe
- Check for visible damage at the Cryo-Cooler, cables and connectors
- Check the LN2 transfer lines for damages, over bending and icing at connections